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Original article:

Effect of sleep deprivation on audio-visual reaction time in resident doctors – a measure of task performance

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Abstracts:

Background: Sleep deprivation accounts for impaired perception, difficulties in concentration, vision disturbances and slower reactions. Resident doctors experience acute sleep loss during their 24 hr duty period superimposed on a chronic sleep deprived state.

Objective: The purpose of this study was to evaluate the effect of sleep deprivation on auditory reaction time and visual reaction time (task performance) in resident doctors due to extended duty hours.

Methodology: The audio-visual reaction time was measured at the start and end of 24 hr duty period in 30 resident doctors. Digital Display Response Time apparatus was used to measure the reaction time.

Results: The audio-visual reaction time was increased significantly ($p<0.05$) at the end of the 24 hr duty period. **Conclusion:** 24 hrs of sleep deprivation as a result of extended duty hours significantly increases the audio-visual reaction time. This decreases the task performance in resident doctors, increases lapses in concentration and causes cognitive slowing. All of this might become an issue in relation to patient safety.

Key words: auditory reaction time, sleep deprivation, visual reaction time

Introduction:

Sleep of shorter duration than the average basal need of 7 to 8 hours per night in adults causes sleep deprivation (SD) [1]. SD has detrimental effect on one's health [1] and is associated with deterioration of neurobehavioral performance [2]. Failure to gain enough sleep per night can produce a wide array of effects ranging from daytime sleepiness, to clumsiness, to general decreased cognitive performance [3].

Available literature points to SD attenuating a person's ability to perform a variety of psychomotor tasks designed to measure neuromuscular function. Reaction times, both simple and choice have been most frequently used to assess the effects of SD on psychomotor ability. SD has been associated with longer reaction times and reduced force on a simple and choice reaction time test [4]. Reaction time is the time interval between the application of a stimulus and the appearance of appropriate voluntary response by a subject as rapidly as possible. It is a measure of function of sensorimotor association and performance of an individual. It involves stimulus processing, decision making, and response programming [5]. SD has deleterious effects on task performance in the form of audio visual reaction time because it causes mental fatigue. The human brain needs adequate sleep to recover from fatigue.

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Extended working hours are a requirement of many professions including medical residents. To deliver patient care a physician depends on his cognitive skills and also has to be vigilant. In 1971, Friedman et al. found that residents who had been on call the night before made more errors in reading an electrocardiogram than their rested colleagues [6].

Another study published in the Lancet in 1998 examined the effect of SD on surgical manual dexterity in a Latin square design [7]. The study reported 20% more errors and 14 % longer time duration to complete tasks in surgeons who had not slept in comparison to those who had experienced a full night's sleep. The reduction in performance after 24 hrs of sleep loss has been equated to the effect of a 0.1% blood alcohol concentration [8, 9]. This comparison has received much attention because a physician with a blood alcohol level of 0.1% would be considered unfit for duty [10].

There have been various studies quantifying the effect of SD on cognitive performance [3] and behaviour of physicians [2] but there is paucity of such data for the resident doctors in India. The resident doctors here are routinely required to undergo acute SD combined with chronic sleep restriction. "What is the effect of sleep deprivation on the task performance of resident doctors?" was the question that led to this study.

Aims & Objectives:

1. To evaluate the effect of SD on auditory reaction time (ART) and Visual reaction time (VRT) in resident doctors.
2. To compare the effect of SD on ART and VRT in males and females

Material and Methods:

The study was a cross sectional comparative study. Research procedure was approved by the Institutional Ethics Committee of Seth GSMC and KEM Hospital. Procedures were compliant with ethical principles for medical research described in the Declaration of Helsinki.

All residents in the Medicine and Surgery departments at our institute were invited for the study. 30 resident doctors (15 Male and 15 female) belonging to the age group 26 - 31 years and fulfilling the required criteria were selected based on a first come, first serve basis. All participants completed the study.

Inclusion criteria:

- All resident doctors in the medicine and surgery departments with irregular sleeping habits.

Exclusion criteria:

- History of any ear disease, other sleep disorders, mental or neurological disorders.
- History of smoking, drinking alcohol, consuming tea or coffee more than 4-5 cups a day or ingesting any other central stimulant or suppressive drugs.
- SD due to pain, drugs, medical diseases (CNS disorder, diabetes etc.).

The participants were explained the detailed procedure of the study and their written informed consent was obtained. Digital Display Response Time apparatus from Anand Agencies, Pune, India was used to record the ART and VRT. The apparatus consists of inbuilt electronic circuits. On the operational side meant for the examiner there are various switches (opening switches) to set the instrument ready for visual or auditory responses. On the other side there are closing switches for right hand and left hand separately and red and green bulb to see the light when they glow after switching on by the examiner. There is a partition in the middle so that the activities of the examiner will not affect the subject and thus avoid errors in record of actual

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reaction time. The instrument has a display accuracy of 0.001 sec.

The A-V Reaction time was recorded in a quiet room to avoid any disturbances. As soon as the stimulus was perceived by the subject, they were asked to respond by pressing the response switch. This procedure was demonstrated and the participants were made to practice the same. The interval between the stimuli was randomly varied from 2-5 seconds. VRT for red and green colour & ART for high pitch and low pitch sounds were recorded separately at the start of 24 hr duty period and at its end. Thus each participant served as his/ her own control. ART and VRT were recorded thrice and the least of the three readings was considered for further analysis.

Wilcoxon matched pairs test (non-parametric data) was used to compare the difference in ART and VRT at the start and end of 24 hr duty period. Mann-Whitney test was used to find out the difference of A-V reaction time between males and females, at the start and end of 24 hr duty period. The level of significance was set at probability value < 0.05, power of study was at 80% and α-error was at 5%. For statistical analysis, software Graphpad Instat DTCG (version 3.1) was used.

Observations and Result:

The study included 30 participants between the ages 26-31 yrs. Their mean age was 27.83 ± 1.206 yrs. The mean age of 15 male participants was 27.8 ± 1.207 yrs. and that of the 15 female participants was 27.86 ± 1.246 yrs.

Table 1: Comparison of A-V Reaction time between males and females at the start of duty

	VISUAL REACTION TIME		AUDITORY REACTION TIME	
Stimulus	RED	GREEN	LOW PITCH	HIGH PITCH
Male	134.93 ± 20.662	143.33 ± 19.279	130.40 ± 15.936	149.93 ± 23.328
Female	138.53 ± 26.055	140.33 ± 19.201	126.87 ± 12.660	145.67 ± 22.154
p-value	0.7874	0.663	0.4936	0.6186

Table 1 shows the mean value of ART and VRT for males and females at start of 24 hr duty period. There is no gender difference in the reaction time, both audio and visual, at the start of the 24 hr duty period ($p>0.05$).

VRT for both red and green colour and the ART for both low pitch sound and high pitch sounds increased significantly in all participants ($p<0.0001$) at the end of 24 hr duty period as shown in Table 2.

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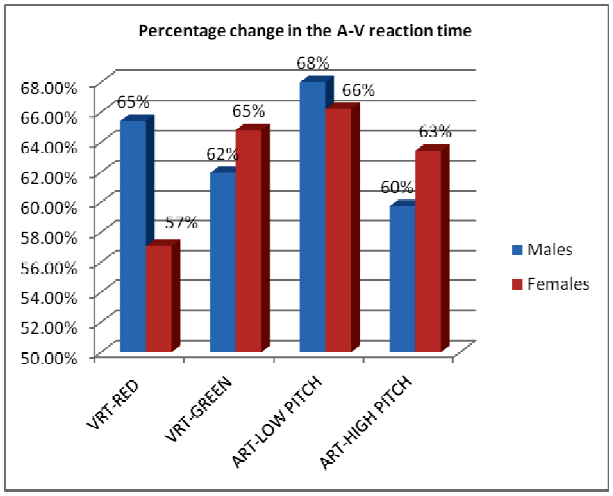
Table 2: Difference in the A-V Reaction time in resident doctors before and at end of 24 hr duty period

	VISUAL REACTION TIME		AUDITORY REACTION TIME	
STIMULUS	RED	GREEN	LOW PITCH	HIGH PITCH
BEFORE	136.73 ± 23.177	141.83 ± 18.967	128.63 ± 14.255	147.80 ± 22.456
AFTER	220.40 ± 17.278	231.70 ± 13.611	214.97 ± 20.767	238.77 ± 10.779
p-VALUE	<0.0001	<0.0001	<0.0001	<0.0001

Figure 1: Percentage change in A-V Reaction time after 24 hrs of Sleep Derivation in resident doctors



VRT increased by more than 50% in both males and females, as seen in Figure 1

Discussion:

The present study evaluated the effect of 24 hrs of sleep deprivation on auditory and visual reaction time in resident doctors.

The main findings of our study showed an increase in both ART and VRT at the end of 24 hr sleep deprivation. The VRT (red and green colour) & ART (high pitch and low pitch sound) were increased significantly at the end of 24 hrs. of SD. VRT for red colour increased by 61.19% and for green colour by 63.36%. ART for low pitch was increased by 68.67% and for high pitch by 61.54%. Reaction time for low pitch sounds was the maximally affected. Our study findings showed that the increase in A-V reaction time after 24 hrs of SD was highly significant ($p<0.0001$).

Wlodarczyk D, Jaskowski P, et al. in their study found that SD has been associated with longer reaction times and reduced force on a simple and choice reaction time test [4]. Other studies have shown

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that SD ranging from 30 to 64 hrs influence simple and choice reaction time significantly [11]. P Bartel, W Offermeier, F Smith, P Becker studied the effect of SD on 33 anaesthesia residents using a variety of tests progressing from simple to complex and sequential. The battery of tests was conducted over a period of 35 mins. They found that group percentage changes between baseline and after SD revealed 6–12% of prolongation of reaction time [12]12. The extent of deterioration in RT was relatively close to 9% in a previous study after 22 hours of continuous wakefulness in non-medical personnel [13]. Dixit A et al. studied the effect of 24 hr SD on psychomotor performance in 30 undergraduate medical students. They found that the tasks requiring sustained attention were affected by sleep deprivation and the effect was more on judgment ability than on response speed [14]. Perez-Olmos I, Ibanez-Pinilla M have studied the effects of SD on attention performance in 180 undergraduate medical students in a prospective longitudinal cohort study design [15]. They have found a progressive deterioration of attention with SD duration.

In our study we found that VRT for red colour and ART for low pitch sound increased more in male resident doctors by 8% and 2% respectively. On the other hand the VRT for green colour and ART for high pitch sound showed a greater increase of 3% in the female subgroup. In both the genders reaction time for low pitch sound increased maximally as compared to the other stimuli. Relative difference in response in males and females depend upon the characteristic of the stimulus.

Corsi-Cabrera M, Sanchez AI et al. found that after SD, the reaction time among males was 30% longer than under the control conditions, while the respective parameter among females increased only by 11% [16]. It seems that the effects of SD may be milder in women, allowing them to better cope with environmental demands under conditions of sleep loss. However, in another study Blatter K, Graw P et al. found that the data shows a reverse relationship regarding the reaction time: it takes a longer time for the women to react (by pushing a button when a red point appears), but they make fewer mistakes than men do [17]. Many other study results point out faster reaction times in males than in females in almost every age group both in choice as well as simple reaction time paradigms [18, 19, 20]. Additionally, more practice did not reduce the female disadvantage.

The results obtained in our study are also consistent with the study of Choo et al [21], Karakorpi et al [22] who also reported decreased performance during acute SD using simple reaction time. Wilkinson et al [23], Smulders et al [24], Wright and Badia [25], Frey et al [26] reported increased reaction times in acute SD using choice reaction time.

Critical thinking, analytical reasoning and making quick decisions for patient management are of utmost importance. The implications of these results are in establishing the need to set limits for work hours, based on scientific evidence, as well as for increased efforts that will improve both patient safety and optimise student learning.

Conclusion:

We conclude that SD significantly increases the reaction time to various stimuli, leading to a decrease in the task performance, lapses in concentration and cognitive slowing. Sleep deprivation affects both the genders equally, though the effect measured varied, depending on the characteristics of the stimuli. In occupations such as medicine, such a decrease in performance can be detrimental and lead to undesired outcomes and is a cause of concern with respect to

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patient safety. A further study to establish a correlation with the duration of SD and A-V reaction time is needed so as to propose guidelines constraining the duty hours of the residents. Effect of anxiolytic drugs/mood enhancer substances like caffeine to increase efficacy of resident doctors during their duty periods also needs further study.

Abbreviations:

SD: Sleep deprivation

CNS: Central Nervous system

ART - Auditory reaction time

VRT - Visual reaction time

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